# APPENDIX E
# GROUND PENETRATING RADAR SURVEY

HAGER-RICHTER
GEOSCIENCE, INC.

# GROUND PENETRATING RADAR SURVEY
# RAYMARK SITE
# STRATFORD, CONNECTICUT

*Prepared for:*

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File 94J01
March, 1994

# 0. EXECUTIVE SUMMARY

Hager-Richter Geoscience, Inc. conducted a ground penetrating radar (GPR) survey at portions of the Raymark Site, Stratford, Connecticut for Halliburton NUS Corporation (HNUS) on March 28-31, 1994. The GPR survey was conducted in three areas of the Site, the Morgan-Francis Property, the Spada Property, and the Housatonic Boat Club Property, totaling more than 50 acres. The properties are located in commercial and residential districts.

According to information provided by HNUS, industrial waste was known to have been received and used as fill on the three properties. The waste disposed on the properties was mixed with soil prior to placement on the properties.

The scope of work as stated by HNUS in the technical specifications is "to determine the presence, location, and characterization of wastes disposed of at each area. Features of interest include, but are not limited to buried vessels, utility conduits, and the horizontal and vertical limits of the waste."

The GPR survey was conducted at locations specified by HNUS in the accessible portions of the three properties of interest, and consisted of 23 traverses totaling about 9100 feet of profile.

The results of the GPR survey for the three properties are as follows:

Morgan-Francis Property: The records for all GPR traverses exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet in the southwest corner of the area to more than 14 feet in the central portion of the area. The GPR data also indicate that buried objects are widespread in the fill. No buried vessels or utilities were identified.

Spada Property: The records for all GPR traverses exhibited signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet along the west edge of the Property, along Ferry Boulevard, to more than 12 feet behind 220 Ferry Boulevard. The GPR data also indicate that buried objects are widespread in the fill. No buried vessels were identified.

Housatonic Boat Club Property: The records for most GPR traverses exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 1-2 feet along the east edge of Shore Road to more than 6 feet along the edge of the Housatonic River. The area west of Shore Road exhibits signatures characteristic of natural ground and is not interpreted to be fill. The GPR data also indicate that buried objects are widespread in the fill. No buried vessels were identified.

GPR Survey
Raymark Site
Stratford, Connecticut
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# 1. INTRODUCTION

**1.1 General** Hager-Richter Geoscience, Inc. conducted a ground penetrating radar (GPR) survey at the Raymark Site, in Stratford, Connecticut for Halliburton NUS Corporation (HNUS) of Wilmington, Massachusetts on March 28-31, 1994. The GPR survey was conducted on three properties of interest within the Site, the Morgan-Francis Property, the Spada Property, and the Housatonic Boat Club Property, totaling more than 50 acres. The survey is part of a larger environmental site evaluation being conducted by HNUS for the United States Environmental Protection Agency.

The Site is located in a mixed commercial and residential area of Stratford, Connecticut. Figure 1 shows the general location of the three properties of interest. The Morgan-Francis Property consists of an open grass and soil covered field with slightly undulating topography. The Spada Property is a commercial section along Ferry Boulevard and is partially covered by asphalt. The ground surface of the Spada Property dips gently from Ferry Boulevard to Ferry Creek at the east. The Housatonic Boat Club Property consists of a flat open parking area and a street, both covered with asphalt.

According to information provided by HNUS, industrial waste was known to have been received and used as fill in the three properties of interest. The fill material consists of native soils mixed with asbestos and other manufacturing wastes.

**1.2 Scope of Work** The scope of work for the GPR survey, as stated by HNUS in the technical specifications, is "to determine the presence, location, and characterization of wastes disposed of at each area. Features of interest include, but are not limited to buried vessels, utility conduits, and the horizontal and vertical limits of the waste."

**1.3 Personnel and Schedule** Jeffrey Reid and Michael Swierz of Hager-Richter conducted the GPR field operations. The project was managed by Ms. Heather Ford of HNUS. Mr. Walter Martin of HNUS specified the areas of survey and order of priorities for the survey, coordinated, and observed in part the field operations. Preliminary interpretations of the GPR data were discussed with Mr. Walter Martin of HNUS at the end of each filed day. A verbal report of the results was provided to Ms. Ford and Mr. Martin by telephone on April 5, 1994. Final interpretation and analysis of the GPR data were completed at the Hager-Richter offices. Original data and field notes will be retained in the Hager-Richter files for a minimum of seven years.

# 2. EQUIPMENT AND PROCEDURES

## 2.1 General

*2.1.1* ***Field Work.*** A Geophysical Survey Systems, Inc. Model SIR-3:VDU-38 ground penetrating radar system was used for this survey. The system consists of an electronics unit, power supply, graphic recorder, color video display unit and transmitting/receiving antenna. Figure A-1 shows the elements of the GPR system. The transmit/receive antenna is housed in a box that is moved across the surface. The antenna transmits electromagnetic signals into the subsurface and then detects, amplifies, and displays reflections of the signals in real-time on a graphic recorder and a color video display unit. The result is a radar record of the subsurface. The data are also recorded on a tape recorder for later computer processing and detailed interpretation.

The maximum depth of penetration of the GPR signal and the resolution of the reflections are controlled in part by the frequency of the antenna used and in part by the electrical properties of the subsurface. The total time during which radar signals are recorded can be varied from a few to 1,000 nanoseconds (nsec). However, there is a trade-off between total time, corresponding to depth range, and resolution. As the total time of recording is increased, the resolution of the GPR records decreases. For a given site, the total time window is set to detect features located somewhat below the maximum expected target depths.

*2.1.2* ***Interpretation.*** The horizontal axis of a GPR record represents distance across the surface and the vertical axis represents round-trip travel time of the radar signal. The round-trip travel time can be converted to approximate depth by correlating with reflections from targets of known depth or by using handbook values of velocities for materials in the subsurface. For those sites where the subsurface is electrically heterogeneous, the travel times of the radar signal may be different in the various materials, and the vertical scale for the radar records is not necessarily uniform with depth.

The reflections in a GPR record are produced by spatial changes in the physical properties (e.g., type of material, subsurface fluids, porosity, etc.) and related changes in the electrical properties (dielectric constant) of the subsurface materials in the path of the signals. The greater the difference in electrical properties between two materials in the subsurface, the stronger the reflection observed in the GPR record.

The size, shape, and amplitude of the GPR reflections are the characteristics that are considered in the interpretation of the data from any site. Because the electrical properties of metal USTs, utilities, and conduits different significantly from those of the soils in which they are buried, such objects produce GPR reflections with high amplitude and distinctive shapes that permit identification with a high degree of reliability. Most other objects, although readily detectable, require "ground truth" for identification. Only excavations provide positive identification for most objects identified in GPR surveys.

## 2.2 Limitations of the Method

There are limitations of the GPR technique as used to detect and/or locate fill: (1) surface conditions, (2) electrical conductivity of the ground, and (3) contrast of the electrical conductivities of the fill and the natural soil. None of these limitations is controlled by the operator.

The condition of the ground surface can affect the quality of the GPR data and the depth of penetration of the GPR signal. Portions of the Raymark Site were covered with high grass, bushes, debris, obstacles, soil mounds, etc., limiting survey access and the coupling of the GPR antenna with the ground. In general, such conditions were limited in extent, and were not a significant problem for the subject survey.

The electrical conductivity of the ground determines the attenuation of the GPR signals, and thereby limits the maximum depth of exploration. The GPR signal does not penetrate clay-rich soils or soils saturated with brackish or salt water. The Housatonic Boat Club Property is underlain by soil and/or fill saturated with brackish or salt water. The GPR signal penetrated to the water table, but not below it.

A definite contrast in the electrical conductivities of the fill and the natural soil is required to obtain a reflection of the GPR signal. If the contrast is too small then the reflection may be too weak to recognize, and the interface can be missed. Based on the results of the GPR test survey and the test pits at the Raymark Site, it is apparent that there is a significant enough electrical conductivity contrast between the fill material and the natural soil to produce an interpretable reflection.

Accurate determination of the depth to any interface requires calibration of the site specific GPR signal velocity. Four test pits were excavated by HNUS on the Morgan-Francis Property for the calibration of the velocity of the fill. The time-to-depth conversion established from the test pits and the GPR data was used throughout the three properties. If the fill composition or type varies significantly across the Site, the time-to-depth conversion will also change significantly, thus producing errors in the depth calculations.

Interpretation of GPR data is subjective. As noted above, "ground truth" through correlation with borings and excavations is required for positive identification of most objects detected on the basis of GPR data.

### 2.3 Site Specific

*2.3.1* ***General.*** HNUS specified the properties of interest, line locations, and order of priority for the GPR survey at the Raymark Site. The beginning and end of each GPR line was staked in the field by HNUS for surveying at a later date. The GPR antenna was pulled by hand for the Morgan-Francis Property, and was pulled behind a vehicle for the other two properties of interest. This report was prepared before the surveyed locations of the GPR traverses or Site Plans became available. Therefore the drawings should be considered "sketch plans," and the scales are approximate.

*2.3.2* ***GPR Test Survey.*** As directed by HNUS, a GPR test survey was conducted on the Morgan Francis Property at the start of the field operations. The test survey was conducted to determine the optimum antenna frequency to delineate the wastes and buried objects. Based on qualitative comparison of the test data acquired with antennas of varying frequencies (120 MHz, 300 MHz, and 500 MHz), and with the concurrence of the HNUS Site representatives, the 120 MHz antenna was selected for use in the remainder of the survey because it yielded the greatest signal penetration with sufficient resolution to meet the survey objectives. A 120 nanosecond time window was chosen based on the assumed depths to the features of interest.

*2.3.3* ***Calibration of GPR Data.*** Four test pits were excavated on the Morgan-Francis Property by HNUS. The test pit locations were selected in concurrence with the HNUS Site representatives based on the locations best suited for calibration of the GPR data. Only two of the test pits were completed to the estimated depth of the fill/natural interface based on the GPR data. The time-to-depth conversion for the fill as established from the combination of the test pit data and the GPR data was determined to be 8.3 nsec./ft for the material above the water table. The time-to-depth conversion for the material beneath water table is most likely somewhat larger than the 8.3 nsec./foot value. As discussed in Section 2.2, this singe calibration was used to determine the depth of the fill based on the GPR data for the entire Raymark Site. If the electrical characteristics of he fill vary across the Site, however, the depth estimates contained herein may be in error.

# 3. RESULTS AND DISCUSSION

The GPR survey at the Raymark Site consisted of 23 traverses totaling about 9100 feet. The depths of the fill/natural interface for the individual GPR traverses are listed in Appendix 1.

Depths given in Appendix 1 are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Site. The conversion for unsaturated fill at the other properties and saturated material at all of the properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in Appendix 1.

HNUS provided a copy of a plan showing the results of a GPR survey conducted by Roy F. Weston, Inc. on the residential properties adjoining the Morgan-Francis Property. An attempt was made to correlate Weston's GPR data with the GPR data collected for this survey. Due to ambiguity in the location of Weston's GPR traverses relative to the current GPR traverses, direct correlation is not possible. The property lines for the adjoining properties are marked on Figure 3.

The GPR signature of fill at the Raymark Site is characterized by a broken and chaotic pattern of reflections. The GPR signature of the natural material is characterized by fairly flat and homogeneous reflections. The interface between the two soils is characterized by a bold undulating reflection as shown in the examples of the GPR traverses. Only a minimum depth to the interface can be established in some portions of the Site. When the reflector indicative of the fill/natural material interface is not present within a GPR record, a minimum depth to the interface is established by using the maximum demonstrable penetration and the time-to-depth conversion established from the testpitting.

## 3.1 Morgan-Francis Property

The GPR survey of the Morgan-Francis Property consisted of nine GPR traverses totaling about 2320 feet. The locations of the GPR traverses and the interpretation of the GPR data are shown in Figure 2. GPR signal penetration varied over the Morgan-Francis Property from 40 nsec. along the south end of Line MF-1 to more than 110 nsec. at center of Line MF-3.

The records for all GPR traverses on the Morgan-Francis Property exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet in the southwest corner of the Property along Line MF-1 to more than 14 feet in the central portion of the Property along Line MF-3. In general, the fill appears to be thinnest along the edges of the Property and thickest in the central portion of the Property. The locations of buried metal objects detected on the basis of the GPR data are shown in Figure 2. No utilities or buried vessels were identified. A typical GPR record for the Morgan-Francis Property is shown in Figure 3.

## 3.2 Spada Property

The GPR survey of the Spada Property consisted of nine GPR traverses totaling about 4900 feet. The locations of the GPR traverses and the interpretation of the GPR data for this Property are shown in Figure 4. GPR signal penetration varied over the Spada Property from 20 nsec. along the west end of Lines 200-1, 280-1, and 300-1 to more than 90 nsec. at east end of Line 200-2.

The records for all GPR traverses for the Spada Property exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet thick along the west edge of the Property, along Ferry Boulevard, to more than 12 feet behind 220 Ferry Boulevard. In general, the fill is thinnest along Ferry Boulevard and thickest to the east along Ferry Creek. The locations of buried metal objects detected on the basis of the GPR data are shown in Figure 4. No buried vessels were identified for the Spada Property. A portion of a typical GPR record for the Spada Property is shown in Figure 5.

## 3.3 Housatonic Boat Club Property

The GPR survey of the Housatonic Boat Club Property consisted of five GPR traverses totaling about 1880 feet. The locations of the GPR traverses and the interpretation of the GPR data for this Property are shown in Figure 6. GPR signal penetration at the Housatonic Boat Club Property remains fairly constant at approximately 40 to 50 nsec. which represents 5-6 feet. The GPR signal penetration is limited by the top of water table due to the presence of brackish or salt water. For this property, depths to the fill/natural interface can not be determined when it is below the water table.

Most GPR traverses at the Housatonic Boat Club Property exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 1-2 feet along the west edge of Shore Road to more than 6 feet along the edge of the Housatonic River. The GPR records for the area west of Shore Road exhibit signatures characteristic of natural ground and the soils are not interpreted to be fill. The locations of buried metal objects detected on the basis of the GPR data are shown in Figure 6. No buried vessels were identified for the Housatonic Boat Club Property. A portion of a typical GPR traverse for the Boat Club Property is shown in Figure 7.

# 4. CONCLUSIONS

Based on the GPR survey at Raymark Site in Stratford, Connecticut, we conclude the following:

Morgan-Francis Property: The records for all GPR traverses exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet in the southwest corner of the area to more than 14 feet in the central portion of the area. The GPR data also indicate that buried metal objects are widespread in the fill. No buried vessels were identified.

Spada Property: The records for all GPR traverses exhibited signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 2-3 feet along the west edge of the Property, along Ferry Boulevard, to more than 12 feet behind 220 Ferry Boulevard. The GPR data also indicate that buried metal objects are widespread in the fill. No buried vessels were identified.

Housatonic Boat Club Property: The records for many GPR traverses exhibit signatures characteristic of fill. The thickness of fill as interpreted from the GPR data varies from approximately 1-2 feet along the east edge of Shore Road to more than 6 feet along the edge of the Housatonic River. The area west of Shore Road exhibits signatures characteristic of natural ground and is not interpreted to be fill. The GPR data also indicate that buried metal objects are widespread in the fill. No buried vessels were identified.

# 5. LIMITATIONS

This report was prepared for the exclusive use of Halliburton NUS Corporation. Hager-Richter Geoscience, Inc. has performed its professional services, obtained its findings, and made its conclusions in accordance with generally accepted and customary principles and practices in the field of geophysics. No other warranty, either expressed or implied, is made. Hager-Richter Geoscience, Inc. is not responsible for the independent conclusions, opinions, or recommendations made by others based on the information, geophysical data, and interpretations presented in this report.

This geophysical survey included a limited set of data obtained at the project Site and was conducted with limited knowledge of the Site and its subsurface conditions. Hager-Richter Geoscience, Inc. does not assume responsibility for the accuracy of information that was provided to us by others about the Site and its subsurface conditions. The findings provided by Hager-Richter Geoscience, Inc. are based solely on the information described in this document. The conclusions drawn from this investigation are considered reliable; however, there may exist localized variations in subsurface conditions that have not been completely defined at this time. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

GPR Survey
Raymark Industries, Inc. Superfund Site
Stratford, Connecticut
File 94J01 March, 1994

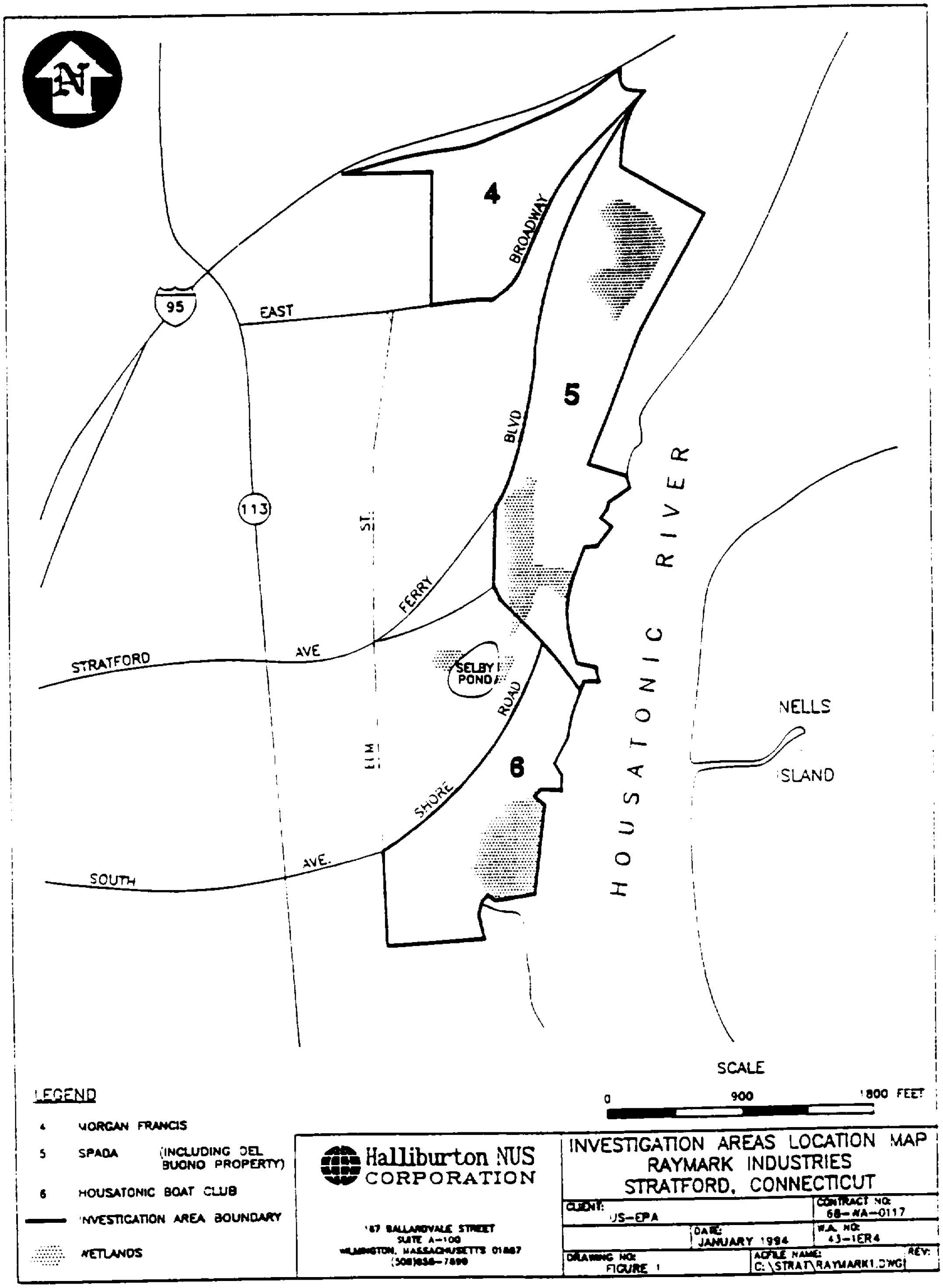



**Figure 1.** Site location. Base map provided by HNUS.

GPR Survey
Raymark Site
Stratford, Connecticut
File 94J01 March, 1994

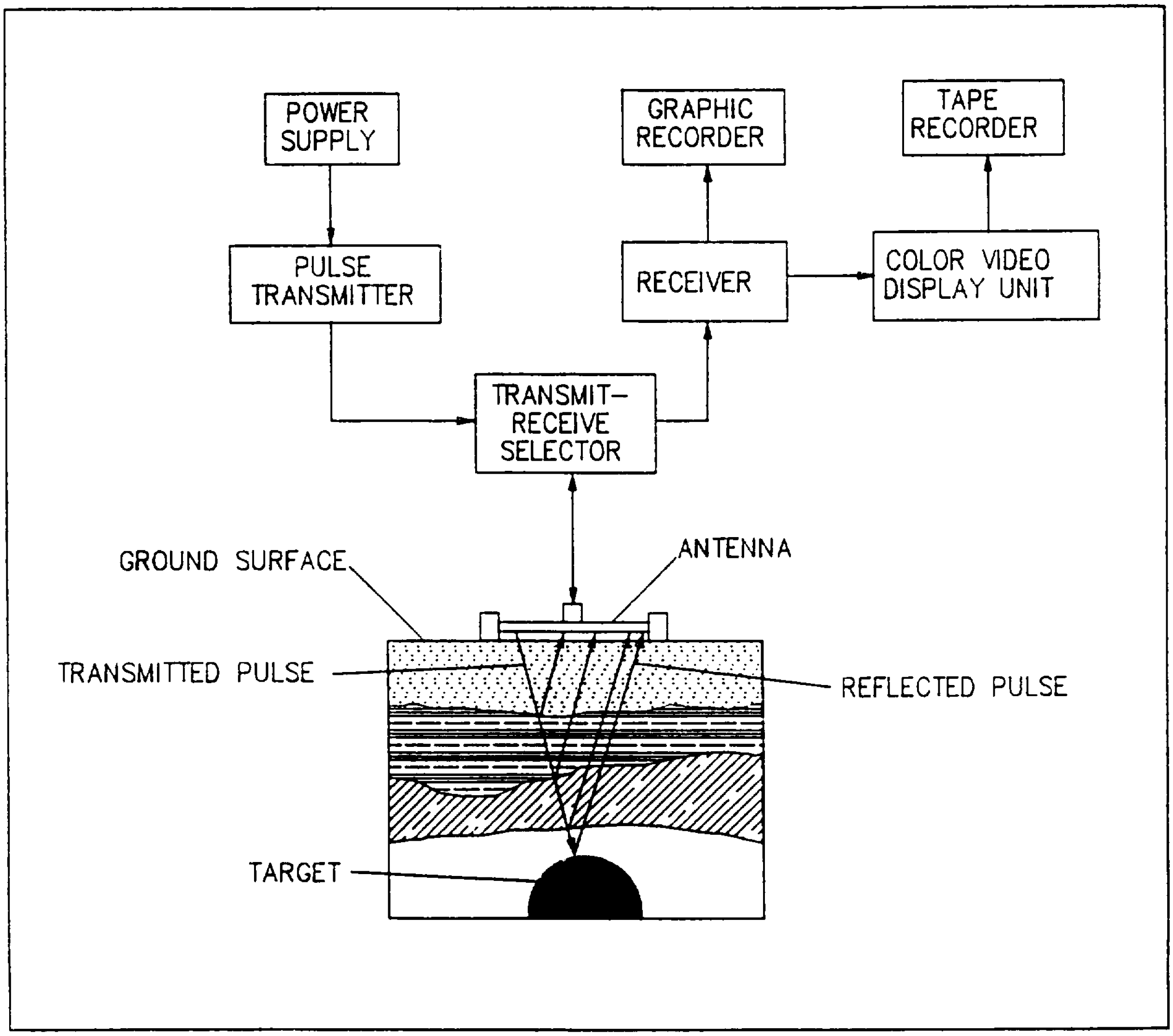
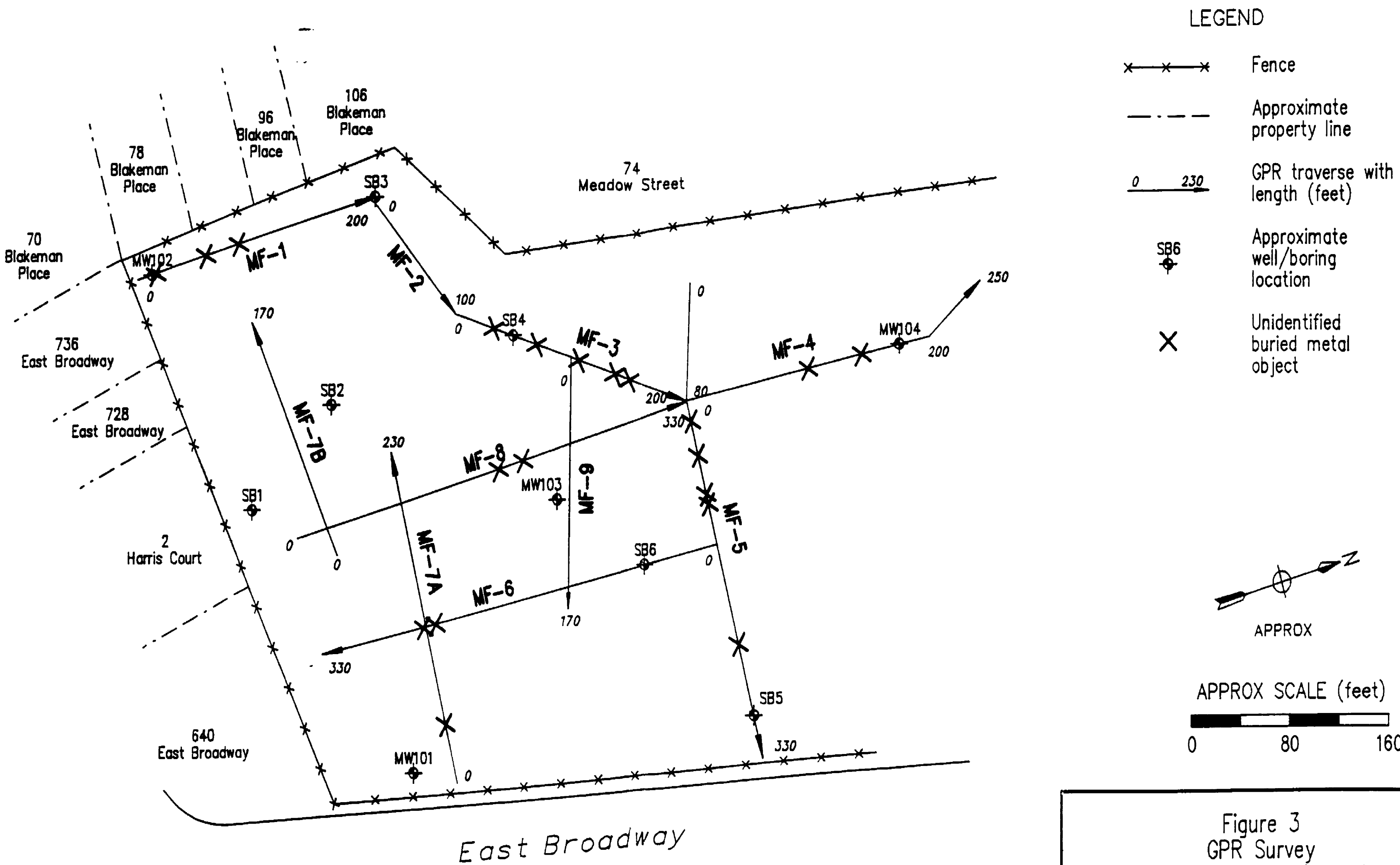



**Figure 2.** The GPR system




NOTE: This plan was produced prior to surveying and should be considered a "sketch plan."

The entire Morgan-Francis Property is underlain by fill material.

Figure 3
GPR Survey
Morgan-Francis Property
Raymark Site
Stratford, Connecticut

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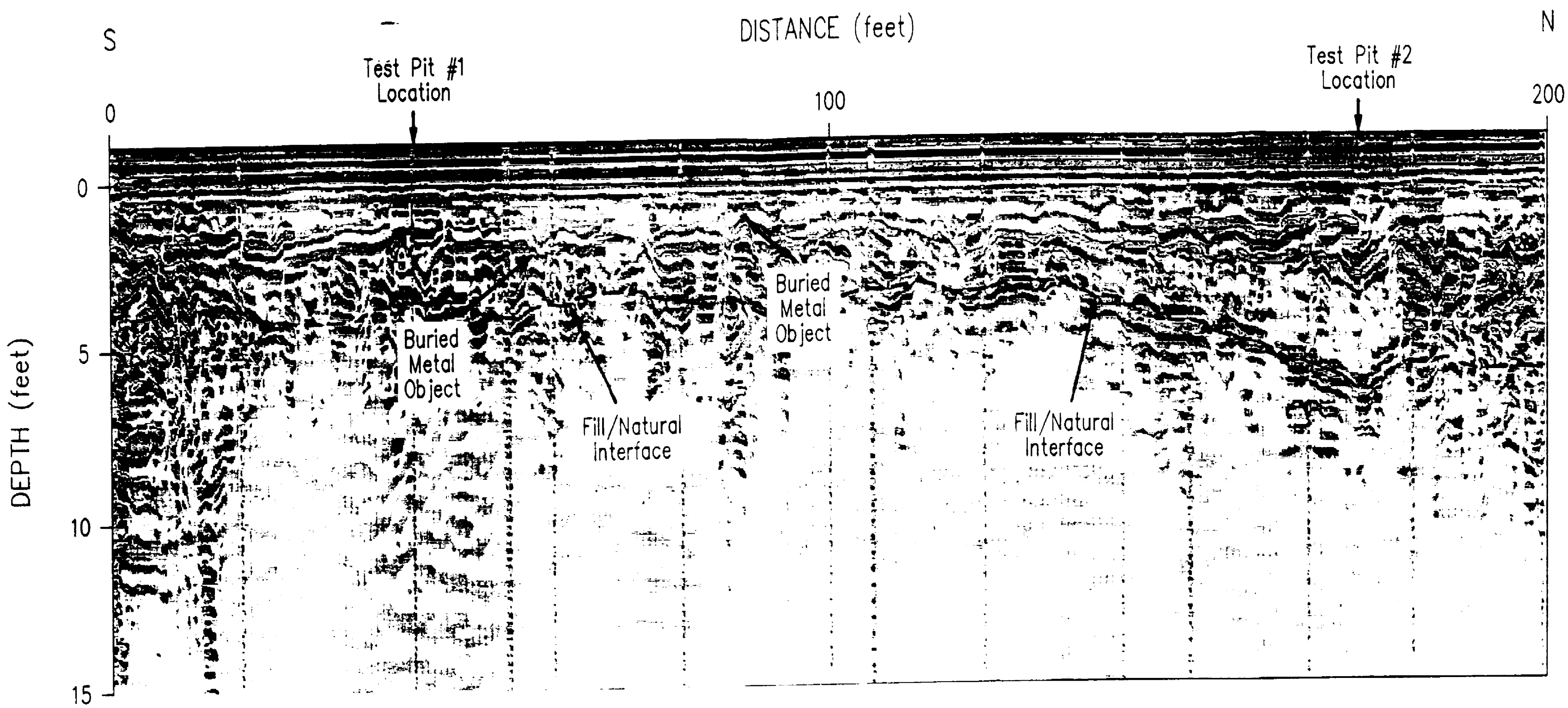


Note: Depth scale is esitmate based on calibration of test data as described in text. The actual time-to-depth conversion for the GPR signal varies with the dielectric properties of the materials in the subsurface and is not necessarily uniform across the property and may vary with depth.

Colors represent relative amplitude of reflected signals. Grey and white are lowest amplitude; brightest colors are highest amplitude.

Accuracy of distances along GPR record is approximately +/- 2 feet.

Figure 4
GPR Traverse MF-1
Morgan-Francis Property
Raymark Site
Stratford, Connecticut

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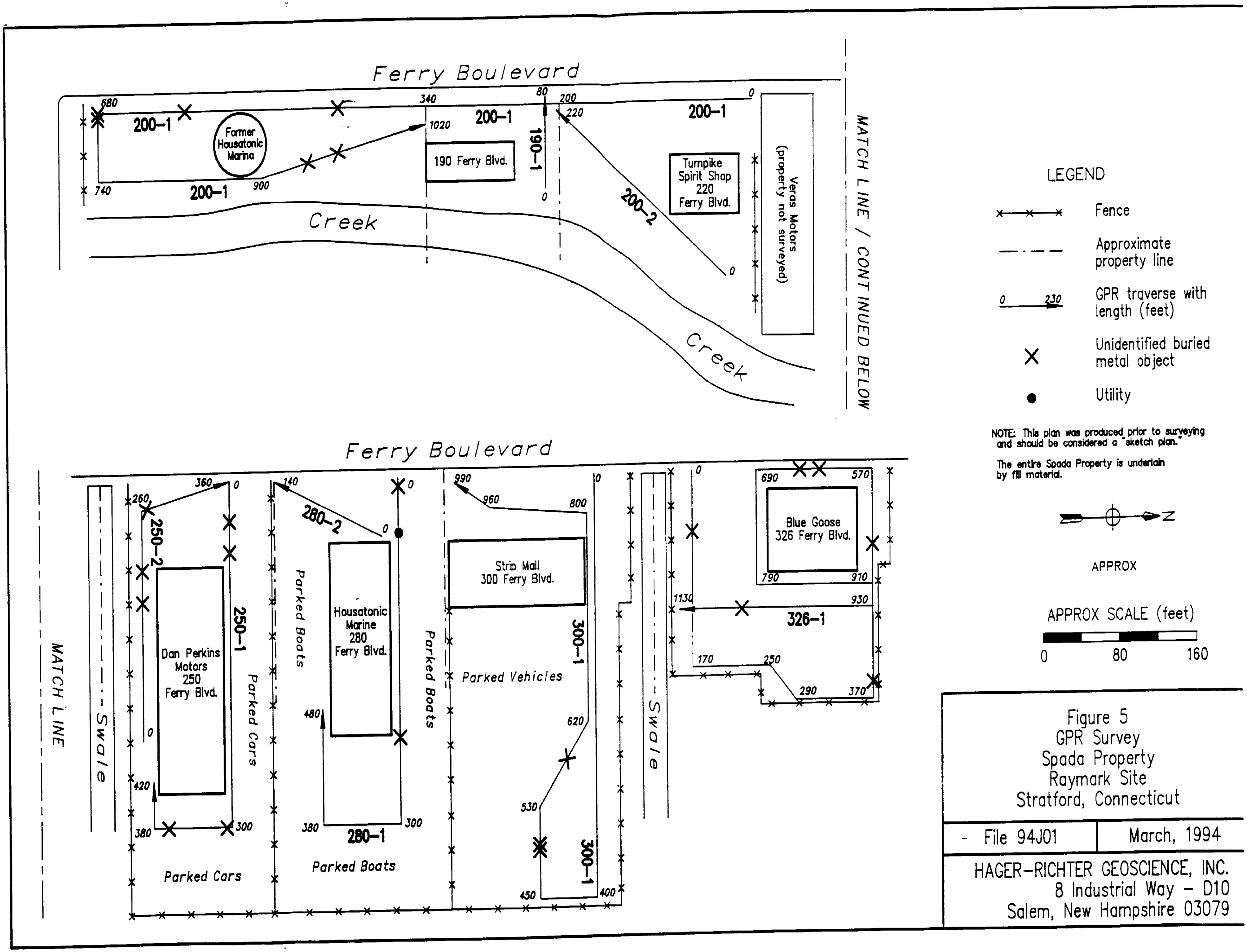


Figure 5
GPR Survey
Spada Property
Raymark Site
Stratford, Connecticut

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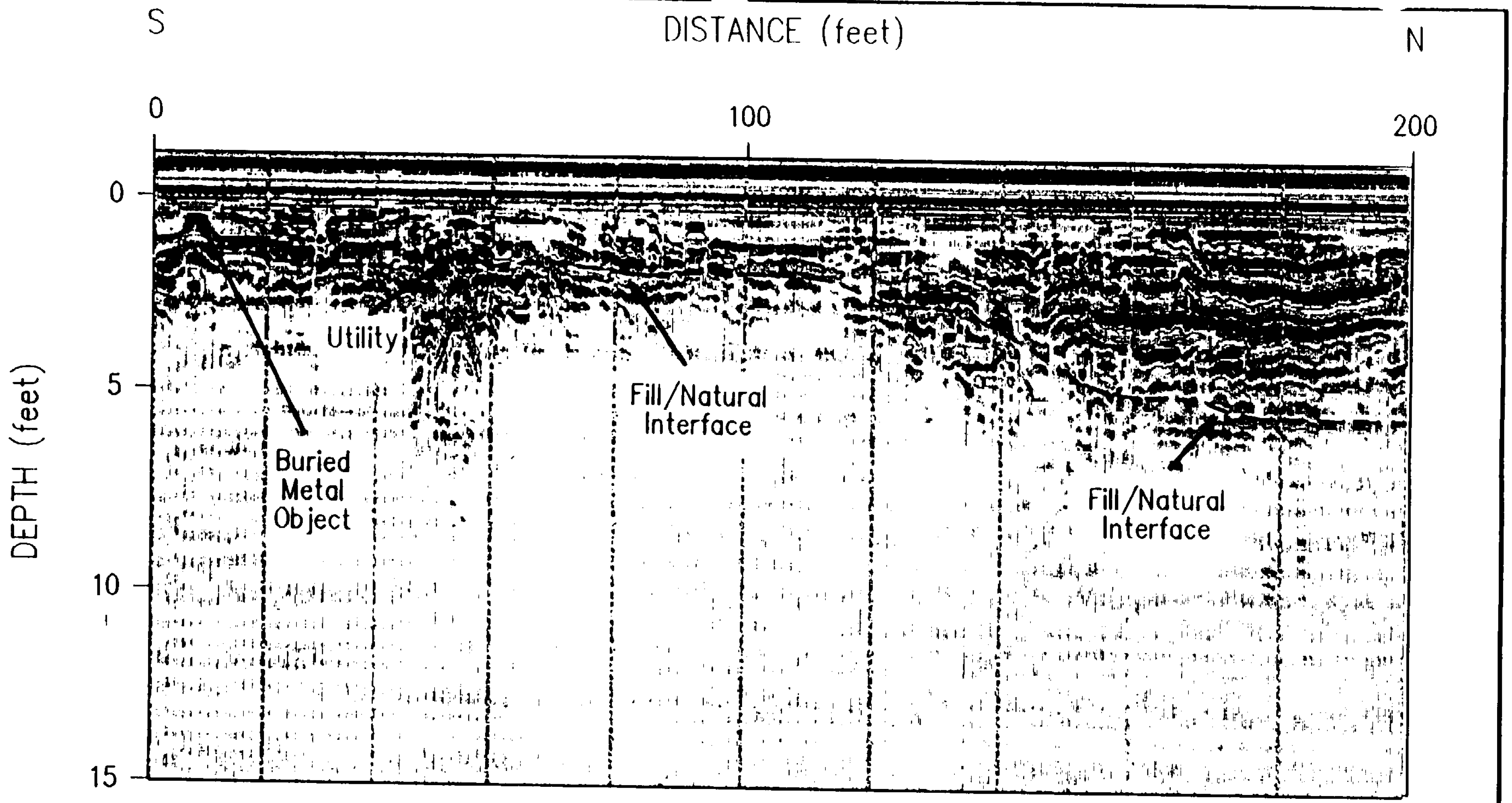


Note: Depth scale is esitmate based on calibration of test data as described in text. The actual time-to-depth conversion for the GPR signal varies with the dielectric properties of the materials in the subsurface and is not necessarily uniform across the property and may vary with depth.

Colors represent relative amplitude of reflected signals. Grey and white are lowest amplitude; brightest colors are highest amplitude.

Accuracy of distances along GPR record is approximately +/- 2 feet.

| |
|---|
| Figure 6<br>Portion of GPR Record for Traverse 280-1<br>Spada Property<br>Raymark Site<br>Stratford, Connecticut |

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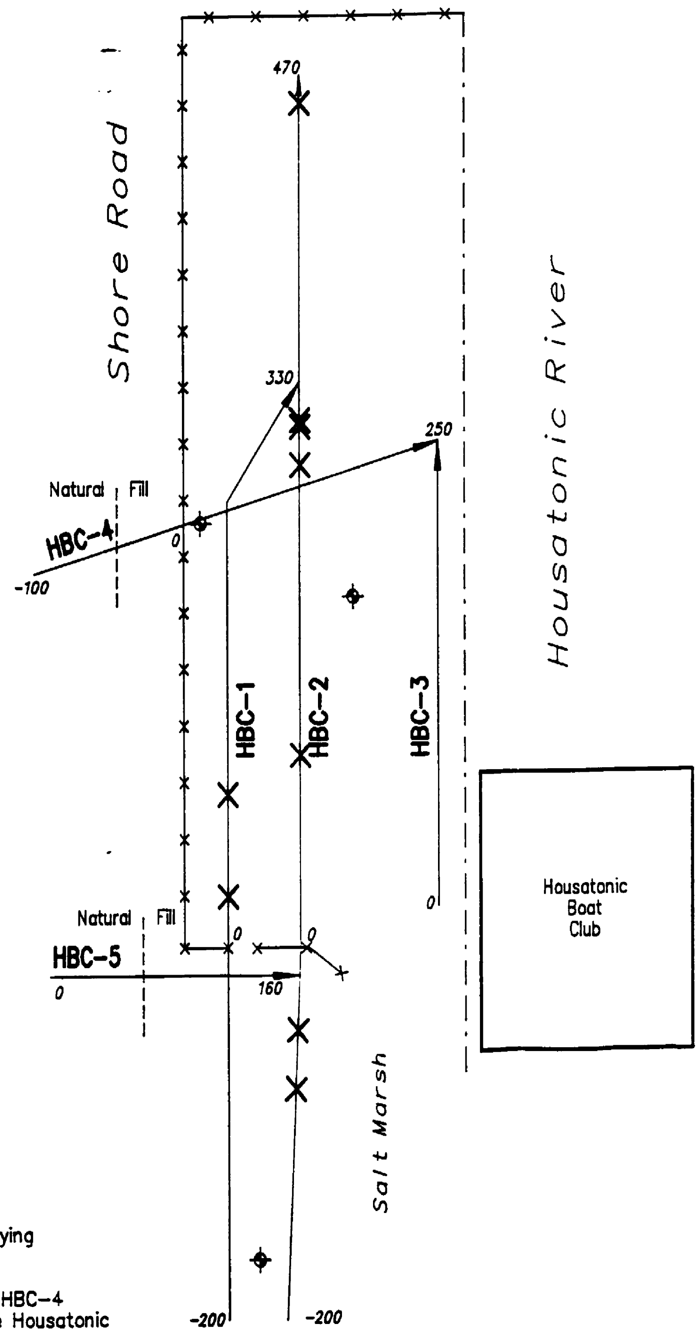


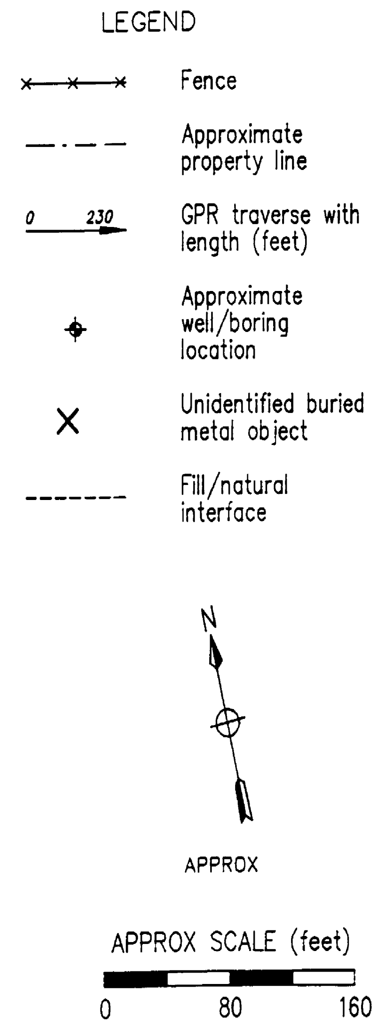


NOTE: This plan was produced prior to surveying and should be considered a "sketch plan."

All lines, except for the west ends of lines HBC-4 HBC-5 are underlain by fill material for the Housatonic Boat Club Property.

Figure 7
GPR Survey
Housatonic Boat Club Property
Raymark Site
Stratford, Connecticut

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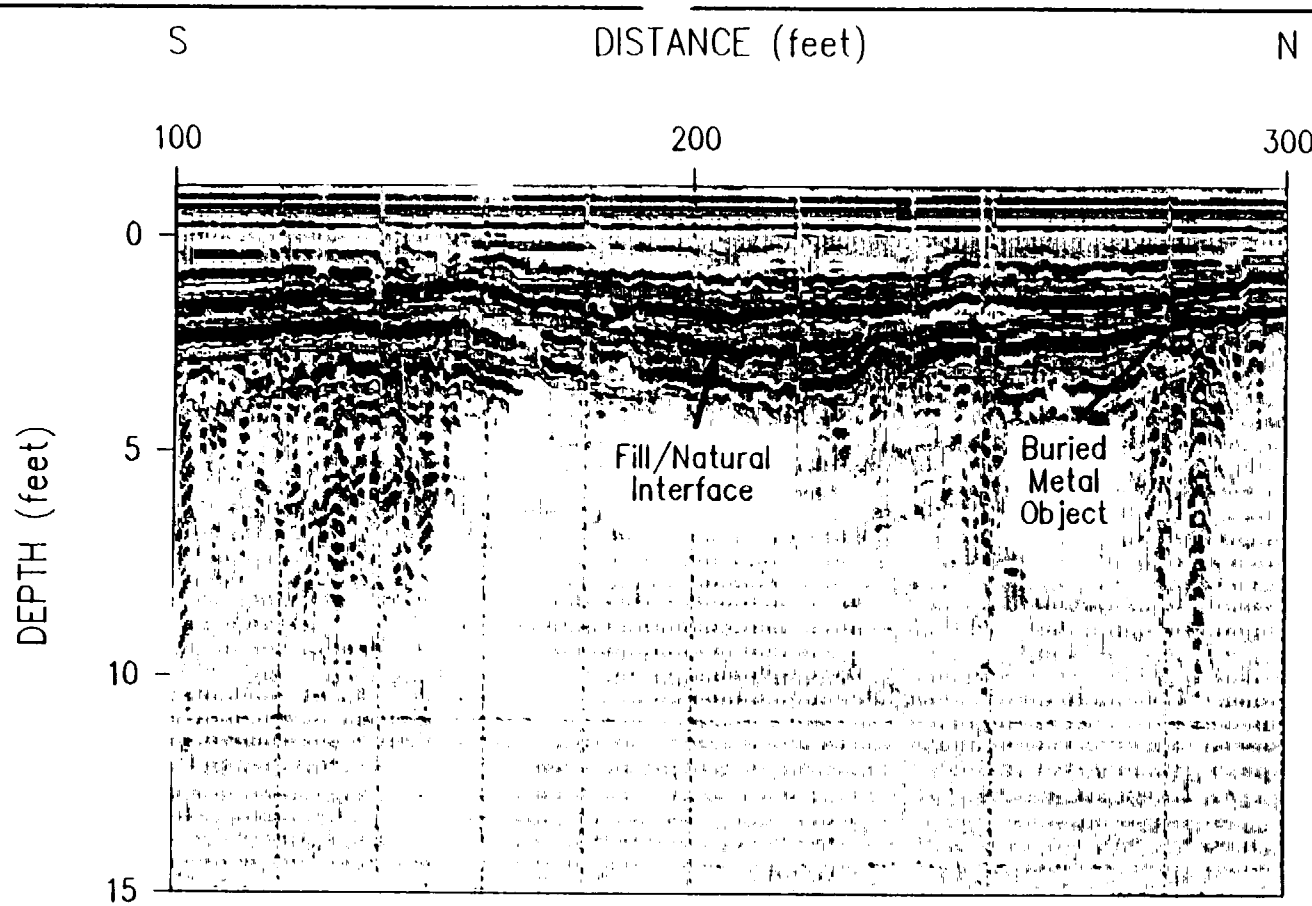


Note: Depth scale is esitmate based on calibration of test data as described in text. The actual time-to-depth conversion for the GPR signal varies with the dielectric properties of the materials in the subsurface and is not necessarily uniform across the property and may vary with depth.

Colors represent relative amplitude of reflected signals. Grey and white are lowest amplitude; brightest colors are highest amplitude.

Accuracy of distances along GPR record is approximately +/- 2 feet.

Figure 8
Portion of GPR Record for Traverse HBC-2
Housatonic Boat Club Property
Raymark Site
Stratford, Connecticut

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GPR Survey
Raymark Site
Stratford, Connecticut
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## APPENDIX 1
## GROUND PENETRATING RADAR RESULTS
## RAYMARK INDUSTRIES, INC. SITE

### MORGAN FRANCIS PROPERTY

| Location | Depth | Location | Depth |
|---|---|---|---|
| **Line MF-1** | | | |
| 0+00 | 3 | 1+20 | 4 |
| 0+20 | 3 | 1+40 | 4 |
| 0+40 | 3 | 1+60 | 6 |
| 0+60 | 3 | 1+80 | 6 |
| 0+80 | 3 | 2+00 | 6 |
| 1+00 | 3 | | |
| **Line MF-2** | | | |
| 0+00 | 6 | 0+60 | 7 |
| 0+20 | 6 | 0+80 | 8 |
| 0+40 | 7 | 1+00 | 9 |
| **Line MF-3** | | | |
| 0+00 | 9 | 1+20 | 14+ |
| 0+20 | 11 | 1+40 | 14+ |
| 0+40 | 11 | 1+60 | 14+ |
| 0+60 | 9 | 1+80 | 12 |
| 0+80 | 9 | 2+00 | 7 |
| 1+00 | 12 | | |
| **Line MF-4** | | | |
| 0+00 | 7 | 1+40 | 7 |
| 0+20 | 7 | 1+60 | 7 |
| 0+40 | 7 | 1+80 | 7 |
| 0+60 | 7 | 2+00 | 8 |
| 0+80 | 6 | 2+20 | 8 |
| 1+00 | 7 | 2+40 | 8 |
| 1+20 | 7 | 2+50 | 6 |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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GPR Survey
Raymark Site
Stratford, Connecticut
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**MORGAN FRANCIS PROPERTY (cont.)**

| Location | Depth | Location | Depth |
|---|---|---|---|
| | **Line MF-5** | | |
| 0+00 | 7 | 1+80 | 8+ |
| 0+20 | 8 | 2+00 | 10+ |
| 0+40 | 8 | 2+20 | 10+ |
| 0+60 | 8 | 2+40 | 11+ |
| 0+80 | 9 | 2+60 | 12+ |
| 1+00 | 9 | 2+80 | 13+ |
| 1+20 | 8 | 3+00 | 13+ |
| 1+40 | 8 | 3+20 | 14+ |
| 1+60 | 8 | 3+30 | 14+ |
| | **Line MF-6** | | |
| 0+00 | 8+ | 1+80 | 8+ |
| 0+20 | 8+ | 2+00 | 8+ |
| 0+40 | 8+ | 2+20 | 8+ |
| 0+60 | 8+ | 2+40 | 8+ |
| 0+80 | 8+ | 2+60 | 8+ |
| 1+00 | 8+ | 2+80 | 8+ |
| 1+20 | 8+ | 3+00 | 8+ |
| 1+40 | 8+ | 3+20 | 8+ |
| 1+60 | 8+ | 3+30 | 8+ |
| | **Line MF-7A** | | |
| 0+00 | 8+ | 1+40 | 8+ |
| 0+20 | 8+ | 1+60 | 8+ |
| 0+40 | 8+ | 1+80 | 8+ |
| 0+60 | 8+ | 2+00 | 8+ |
| 0+80 | 8+ | 2+20 | 8+ |
| 1+00 | 8+ | 2+30 | 8+ |
| 1+20 | 8+ | | |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## MORGAN FRANCIS PROPERTY (cont.)

| Location | Depth | Location | Depth |
|---|---|---|---|
| **Line MF-7B** | | | |
| 0+00 | 10+ | 1+00 | 6+ |
| 0+20 | 10+ | 1+20 | 6+ |
| 0+40 | 10+ | 1+40 | 6+ |
| 0+60 | 9+ | 1+60 | 7+ |
| 0+80 | 8+ | | |
| **Line MF-8** | | | |
| 0+00 | 10+ | 1+80 | 10+ |
| 0+20 | 10+ | 2+00 | 10+ |
| 0+40 | 10+ | 2+20 | 10+ |
| 0+60 | 10+ | 2+40 | 10+ |
| 0+80 | 10+ | 2+60 | 10+ |
| 1+00 | 10+ | 2+80 | 10+ |
| 1+20 | 10+ | 3+00 | 10+ |
| 1+40 | 10+ | 3+20 | 10+ |
| 1+60 | 10+ | 3+30 | 10+ |
| **Line MF-9** | | | |
| 0+00 | 12 | 1+00 | 7+ |
| 0+20 | 11 | 1+20 | 7+ |
| 0+40 | 12 | 1+40 | 7+ |
| 0+60 | 10+ | 1+60 | 8+ |
| 0+80 | 8+ | | |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## SPADA PROPERTY

### Line 190-1

| Location | Depth |
|---|---|
| 0+00 | 8+ |
| 0+20 | 8 |
| 0+40 | 5 |
| 0+60 | 5 |
| 0+80 | 4 |

### Line 200-1

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 2 | 5+20 | 3 |
| 0+20 | 3 | 5+40 | 3 |
| 0+40 | 4 | 5+60 | 4 |
| 0+60 | 4 | 5+80 | 4 |
| 0+80 | 4 | 6+00 | 4 |
| 1+00 | 4 | 6+20 | 5 |
| 1+20 | 4 | 6+40 | 5 |
| 1+40 | 4 | 6+60 | 5 |
| 1+60 | 4 | 6+80 | 6 |
| 1+80 | 5 | 7+00 | 6 |
| 2+00 | 5 | 7+20 | 6 |
| 2+20 | 5 | 7+40 | 6 |
| 2+40 | 4 | 7+60 | 7 |
| 2+60 | 4 | 7+80 | 7 |
| 2+80 | 4 | 8+00 | 8 |
| 3+00 | 4 | 8+20 | 9 |
| 3+20 | 5 | 8+40 | 10 |
| 3+40 | 5 | 8+60 | 10 |
| 3+60 | 5 | 8+80 | 9 |
| 3+80 | 5 | 9+00 | 9 |
| 4+00 | 5 | 9+20 | 9 |
| 4+20 | 5 | 9+40 | 8 |
| 4+40 | 6 | 9+60 | 7 |
| 4+60 | 5 | 9+80 | 7 |
| 4+80 | 4 | 10+00 | 6 |
| 5+00 | 4 | 10+20 | 5 |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## SPADA PROPERTY (cont.)

| Location | Depth | Location | Depth |
|---|---|---|---|
| **Line 200-2** | | | |
| 0+00 | 11+ | 1+20 | 5 |
| 0+20 | 11 | 1+40 | 4 |
| 0+40 | 9 | 1+60 | 4 |
| 0+60 | 9 | 1+80 | 4 |
| 0+80 | 8 | 2+00 | 4 |
| 1+00 | 6 | 2+20 | 4 |
| **Line 250-1** | | | |
| 0+00 | 3 | 2+20 | 7+ |
| 0+20 | 4 | 2+40 | 7+ |
| 0+40 | 5 | 2+60 | 7+ |
| 0+60 | 6 | 2+80 | 7+ |
| 0+80 | 6 | 3+00 | 6 |
| 1+00 | 6 | 3+20 | 6 |
| 1+20 | 6 | 3+40 | 6 |
| 1+40 | 6 | 3+60 | 7 |
| 1+60 | 6 | 3+80 | 7 |
| 1+80 | 7+ | 4+00 | 7 |
| 2+00 | 7+ | 4+20 | 8 |
| **Line 250-2** | | | |
| 0+00 | 8 | 2+00 | 7+ |
| 0+20 | 8 | 2+20 | 7 |
| 0+40 | 7+ | 2+40 | 7 |
| 0+60 | 7+ | 2+60 | 7 |
| 0+80 | 7+ | 2+80 | 7 |
| 1+00 | 7+ | 3+00 | 7 |
| 1+20 | 7+ | 3+20 | 6 |
| 1+40 | 8+ | 3+40 | 5 |
| 1+60 | 8+ | 3+60 | 4 |
| 1+80 | 8+ | | |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## SPADA PROPERTY (cont.)

**Line 280-1**

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 2 | 2+60 | 7 |
| 0+20 | 3 | 2+80 | 7 |
| 0+40 | 4 | 3+00 | 7 |
| 0+60 | 4 | 3+20 | 7+ |
| 0+80 | 4 | 3+40 | 7+ |
| 1+00 | 4 | 3+60 | 7+ |
| 1+20 | 5 | 3+80 | 7+ |
| 1+40 | 6 | 4+00 | 6+ |
| 1+60 | 6 | 4+20 | 6+ |
| 1+80 | 6 | 4+40 | 6+ |
| 2+00 | 6 | 4+60 | 6+ |
| 2+20 | 6 | 4+80 | 6+ |
| 2+40 | 7 | | |

**Line 280-2**

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 6 | 0+80 | 5 |
| 0+20 | 6 | 1+00 | 5 |
| 0+40 | 6 | 1+20 | 4 |
| 0+60 | 6 | 1+40 | 3 |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## SPADA PROPERTY (cont.)

**Line 300-1**

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 2 | 5+20 | 5+ |
| 0+20 | 4 | 5+40 | 5+ |
| 0+40 | 6 | 5+60 | 5+ |
| 0+60 | 7 | 5+80 | 5+ |
| 0+80 | 8 | 6+00 | 5+ |
| 1+00 | 8 | 6+20 | 5+ |
| 1+20 | 8 | 6+40 | 5+ |
| 1+40 | 8 | 6+60 | 5+ |
| 1+60 | 8 | 6+80 | 5+ |
| 1+80 | 8 | 7+00 | 7 |
| 2+00 | 8 | 7+20 | 8 |
| 2+20 | 8+ | 7+40 | 8 |
| 2+40 | 8+ | 7+60 | 8 |
| 2+60 | 8+ | 7+80 | 8 |
| 2+80 | 8+ | 8+00 | 8 |
| 3+00 | 8+ | 8+20 | 7 |
| 3+20 | 8+ | 8+40 | 8 |
| 3+40 | 8+ | 8+60 | 7 |
| 3+60 | 8+ | 8+80 | 7 |
| 3+80 | 8+ | 9+00 | 7 |
| 4+00 | 8+ | 9+20 | 6 |
| 4+20 | 6+ | 9+40 | 5 |
| 4+40 | 4+ | 9+60 | 5 |
| 4+60 | 4+ | 9+80 | 4 |
| 4+80 | 4+ | 10+00 | 4 |
| 5+00 | 4+ | 10+20 | 3 |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

## SPADA PROPERTY (cont.)

**Line 326-1**

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 3 | 5+80 | 7 |
| 0+20 | 4 | 6+00 | 7 |
| 0+40 | 5 | 6+20 | 7 |
| 0+60 | 5 | 6+40 | 7 |
| 0+80 | 5 | 6+60 | 7 |
| 1+00 | 5 | 6+80 | 6 |
| 1+20 | 5 | 7+00 | 6 |
| 1+40 | 6 | 7+20 | 6 |
| 1+60 | 7 | 7+40 | 7 |
| 1+80 | 8 | 7+60 | 7 |
| 2+00 | 8 | 7+80 | 7 |
| 2+20 | 8 | 8+00 | 7 |
| 2+40 | 8 | 8+20 | 7 |
| 2+60 | 8 | 8+40 | 7 |
| 2+80 | 6+ | 8+60 | 8 |
| 3+00 | 6+ | 8+80 | 8+ |
| 3+20 | 6+ | 9+00 | 8+ |
| 3+40 | 6+ | 9+20 | 8+ |
| 3+60 | 6+ | 9+40 | 7+ |
| 3+80 | 8 | 9+60 | 7+ |
| 4+00 | 8 | 9+80 | 7+ |
| 4+20 | 8 | 10+00 | 7+ |
| 4+40 | 8 | 10+20 | 7+ |
| 4+60 | 8 | 10+40 | 7+ |
| 4+80 | 8 | 10+60 | 7+ |
| 5+00 | 7 | 10+80 | 7+ |
| 5+20 | 6 | 11+00 | 7+ |
| 5+40 | 7 | 11+20 | 7+ |
| 5+60 | 7 | 11+40 | 7+ |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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## HOUSATONIC BOAT CLUB PROPERTY

**Line HBC-1**

| Location | Depth | Location | Depth |
|---|---|---|---|
| -2+00 | 1 | 0+80 | 2 |
| -1+80 | 2 | 1+00 | 2 |
| -1+60 | 3 | 1+20 | 2 |
| -1+40 | 3 | 1+40 | 2 |
| -1+20 | 3 | 1+60 | 2 |
| -1+00 | 2 | 1+80 | 2 |
| -0+80 | 2 | 2+00 | 2 |
| -0+60 | 1 | 2+20 | 2 |
| -0+40 | 1 | 2+40 | 2 |
| -0+20 | 1 | 2+60 | 2 |
| 0+00 | 2 | 2+80 | 2 |
| 0+20 | 2 | 3+00 | 2 |
| 0+40 | 2 | 3+20 | 2 |
| 0+60 | 2 | | |

**Line HBC-2**

| Location | Depth | Location | Depth |
|---|---|---|---|
| -2+00 | 3 | 1+60 | 2 |
| -1+80 | 3 | 1+80 | 2 |
| -1+60 | 2+ | 2+00 | 3 |
| -1+40 | 2+ | 2+20 | 3 |
| -1+20 | 2+ | 2+40 | 2 |
| -1+00 | 2+ | 2+60 | 2 |
| -0+80 | 2+ | 2+80 | 2 |
| -0+60 | 2+ | 3+00 | 1 |
| -0+40 | 1+ | 3+20 | 1 |
| -0+20 | 2+ | 3+40 | 2 |
| 0+00 | 1+ | 3+60 | 2 |
| 0+20 | 2 | 3+80 | 2 |
| 0+40 | 2 | 4+00 | 2 |
| 0+60 | 2 | 4+20 | 2 |
| 0+80 | 2 | 4+40 | 2 |
| 1+00 | 2 | 4+60 | 2+ |
| 1+20 | 2 | 4+70 | 2 |
| 1+40 | 2 | | |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.

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**Line HBC-3**

| Location | Depth | Location | Depth |
|---|---|---|---|
| 0+00 | 3+ | 1+40 | 3+ |
| 0+20 | 3+ | 1+60 | 3+ |
| 0+40 | 4+ | 1+80 | 4+ |
| 0+60 | 4+ | 2+00 | 5+ |
| 0+80 | 4+ | 2+20 | 6+ |
| 1+00 | 3+ | 2+40 | 5+ |
| 1+20 | 3+ | 2+50 | 5+ |
| 1+40 | 2 | | |

**Line HBC-4**

| | | | |
|---|---|---|---|
| -1+00 | 0 | 0+60 | 2 |
| -0+80 | 0 | 0+80 | 3 |
| -0+60 | 0 | 1+00 | 4 |
| -0+40 | 0 | 1+20 | 5 |
| -0+20 | 0 | 1+40 | 5 |
| 0+00 | 1 | 1+60 | 6 |
| 0+20 | 2 | 1+70 | 6 |
| 0+40 | 2 | | |

**Line HBC-5**

| | | | |
|---|---|---|---|
| 0+00 | 0 | 1+00 | 2 |
| 0+20 | 0 | 1+20 | 1 |
| 0+40 | 0 | 1+40 | 1 |
| 0+60 | 0 | 1+60 | 2 |
| 0+80 | 1 | | |

Depths shown are depths of the interface between the fill and natural soils. These depths were calculated using a time-to-depth conversion of 8.3 nsec./ft. established from test pits in **unsaturated** materials at the Morgan-Francis Property. The conversion for saturated materials and for unsaturated materials at the other properties may differ. Therefore, the calculated depths to interfaces below the water table may also differ significantly from those in the appendix. Depths with "+" indicate minimum depth of interface.